3-22-00   A

Please type a plus sign (+) inside this box → [+]

+

UTILITY PATENT APPLICATION TRANSMITTAL *(Only for new nonprovisional applications under 37 C.F.R. § 1.53(b))*	*Attorney Docket No.* 13DV13576
	First Inventor or Application Identifier CHRISTOPHER R. HAMMOND
	Title PROCESS PLANNING FOR DISTRIBUTED ETC
	Express Mail Label No. EL231019869US

APPLICATION ELEMENTS
See MPEP chapter 600 concerning utility patent application contents.

ADDRESS TO: **Assistant Commissioner for Patents Box Patent Application Washington, DC 20231**

1. [X] *Fee Transmittal Form (e.g., PTO/SB/17)* (Submit an original and a duplicate for fee processing)

2. [X] Specification [Total Pages 25] (preferred arrangement set forth below)
- Descriptive title of the Invention
- Cross References to Related Applications
- Statement Regarding Fed sponsored R & D
- Reference to Microfiche Appendix
- Background of the Invention
- Brief Summary of the Invention
- Brief Description of the Drawings (if filed)
- Detailed Description
- Claim(s)
- Abstract of the Disclosure

3. [X] Drawing(s) (35 U.S.C. 113) [Total Sheets 6] (informals)

4. Oath or Declaration (unsigned) [Total Pages ___]
a. [ ] Newly executed (original or copy)
b. [ ] Copy from a prior application (37 C.F.R. § 1.63(d)) (for continuation/divisional with Box 16 completed)
   i. [ ] DELETION OF INVENTOR(S) Signed statement attached deleting inventor(s) named in the prior application, see 37 C.F.R. §§ 1.63(d)(2) and 1.33(b).

NOTE FOR ITEMS 1 & 13: IN ORDER TO BE ENTITLED TO PAY SMALL ENTITY FEES, A SMALL ENTITY STATEMENT IS REQUIRED (37 C.F.R. § 1.27), EXCEPT IF ONE FILED IN A PRIOR APPLICATION IS RELIED UPON (37 C.F.R. § 1.28).

5. [ ] Microfiche Computer Program (Appendix)

6. Nucleotide and/or Amino Acid Sequence Submission (if applicable, all necessary)
a. [ ] Computer Readable Copy
b. [ ] Paper Copy (identical to computer copy)
c. [ ] Statement verifying identity of above copies

ACCOMPANYING APPLICATION PARTS

7. [ ] Assignment Papers (cover sheet & document(s))
8. [ ] 37 C.F.R.§3.73(b) Statement (when there is an assignee) [ ] Power of Attorney
9. [ ] English Translation Document (if applicable)
10. [ ] Information Disclosure Statement (IDS)/PTO-1449 [ ] Copies of IDS Citations
11. [ ] Preliminary Amendment
12. [X] Return Receipt Postcard (MPEP 503) (Should be specifically itemized)
13. [ ] * Small Entity Statement(s) (PTO/SB/09-12) [ ] Statement filed in prior application, Status still proper and desired
14. [ ] Certified Copy of Priority Document(s) (if foreign priority is claimed)
15. [ ] Other: _____

16. If a CONTINUING APPLICATION, check appropriate box, and supply the requisite information below and in a preliminary amendment:
[ ] Continuation [ ] Divisional [X] Continuation-in-part (CIP) of prior application No: 09 / 277,460
Prior application information: Examiner _____ Group / Art Unit: 2771

For CONTINUATION or DIVISIONAL APPS only: The entire disclosure of the prior application, from which an oath or declaration is supplied under Box 4b, is considered a part of the disclosure of the accompanying continuation or divisional application and is hereby incorporated by reference. The incorporation can only be relied upon when a portion has been inadvertently omitted from the submitted application parts.

17. CORRESPONDENCE ADDRESS

[X] Customer Number or Bar Code Label **006111** (Insert Customer No. or Attach bar code label here) or [ ] Correspondence address below

PATENT TRADEMARK OFFICE

Name	
Address	
City		State		Zip Code	
Country		Telephone		Fax	

Name (Print/Type)	WILLIAM SCOTT ANDES	Registration No. (Attorney/Agent)	33,582
Signature		Date	3/21/00

Burden Hour Statement: This form is estimated to take 0.2 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, Patent and Trademark Office, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Assistant Commissioner for Patents, Box Patent Application, Washington, DC 20231.

+

PROCESS PLANNING FOR DISTRIBUTED
MANUFACTURING AND REPAIR

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of
Application No. 09/277,460, filed March 26, 1999.

BACKGROUND OF THE INVENTION

The present invention relates to the planning of
various processes and, in particular, to the planning of
manufacturing and/or repair processes conducted at a
number of different sites.

A product is typically comprised of a number of
pieces. However, a product can be just a single piece.
In either case, the piece or pieces of a product have
features. For instance, among the features of a circular
flange there may be a number of holes that are used to
attach the flange to a shaft.

The manufacture of a product begins with the
preparation of one or more engineering drawings for each
piece of the product. Typically, the drawings are
prepared by a design engineer. The drawings set forth
the features of the piece and the material to be used in
producing the piece. For instance, the engineering
drawings for the flange of a jet engine would specify the
diameter, depth, edgebreak requirements and number of
holes to drill in a specific type of material from which
the flange is to be made. The engineering drawings are
typically provided to a process planner, who determines
the sequence in which the features of a piece are to be
made. This sequence is hereinafter referred to as the

1

piece production sequence. To continue with the flange example, the engineering drawings provided to the process planner may specify: (1) that the flange is to be constructed of titanium that is of a specific thickness; (2) five holes are to be drilled around a bolt circle of four inches; (3) the holes are to be one inch deep; and (4) the holes are to be 0.5 inches in diameter ± 0.001 inches. Since it is normally easier to drill holes in stock that are rectangular in shape rather than circular in shape, the process planner is likely to specify a piece production sequence that calls for the holes to be drilled before the titanium stock is given a circular shape. Once the piece production sequence has been completed, the engineering drawings and piece production sequence are provided to the manufacturing engineer, who is responsible for producing the piece. While the engineering drawings and piece production sequence provide a substantial amount of information to the manufacturing engineer, they do not specify how any particular feature is to be produced. Consequently, the manufacturing engineer is left to determine the sequence of operations to be used in producing each feature of the piece. This sequence of operations is hereinafter referred to as the feature process sequence. To continue with the flange example, because of the close tolerance of ± 0.001 inches, the manufacturing engineer might initially drill each of the holes with a slightly smaller diameter drill than 0.5 inches, then use a 0.5 inch reamer and finish with a deburring operation to remove any sharp edges.

In many industries, it is common to attempt to repair worn or damaged parts as an economical alternative to simply replacing such parts. The development of

2

repair processes is similar to the development of manufacturing processes in that one or more engineers determine a sequence of operations to be used in the repair of a particular part. This sequence of operations is herein referred to as the repair process sequence.

In many situations, the manufacture of a product, a piece of a product, or a feature that is common to two or more products is performed at two or more locations. There are a number of possible reasons that a company opts for distributing the manufacturing of its products. For instance, a company may produce a product or piece of a product at two or more sites so as to have a facility that is capable of maintaining at least a portion of the overall production if production at one of the sites is interrupted or severely curtailed. Other possible reasons include the availability of skilled workers in one area relative to another and the availability/cost of the raw materials at one location relative to another. In any event, the manufacture of a product, piece of a product, or feature common to two or more products at two or more sites presently requires that the manufacturing engineer at each site generate a feature process sequence. For similar reasons, it is not uncommon to provide repair services at numerous locations. In this case, it would be typical that a repair process sequence for the repair of a particular part would be generated at each site performing that repair.

BRIEF SUMMARY OF THE INVENTION

The present invention recognizes that the current approaches to manufacturing and repair are inefficient, and that this inefficiency is particularly evident when

3

two or more sites are used to manufacture a product or a portion of a product, or to repair a part. To elaborate, it has been found that with the current approaches, a feature process sequence designed by a manufacturing engineer at one site is, in many cases, inefficient from at least one perspective. For instance, the feature process sequence may turn out fewer parts over time than an alternative sequence. The sequence may also be more expensive from the perspective of the amount and/or type of perishable tooling required to produce the feature. Other inefficiencies may also be present.

Whether or not such inefficiencies exist at a particular manufacturing site, it has generally been found that inefficiencies are present when multiple manufacturing sites are involved in the manufacturing of a particular feature. This is because in most cases a different manufacturing engineer is designing the feature process sequence at each site. As a consequence, the feature process sequences generally vary from site to site. This variation typically results in inefficiencies, such as the previously noted inefficiencies with respect to output per unit time and perishable tooling, at one or more of the manufacturing sites. The current manufacturing approach is also inefficient from the perspective of the time spent by different manufacturing engineers at multiple sites designing feature process sequences for the same feature. Similar inefficiencies arise under the current repair approach when multiple repair facilities are involved in the repair of a particular part.

The present invention provides a method for addressing the inefficiencies in the current approaches

4

and particularly in the situation where the manufacturing of a feature or the repair of a part occurs at multiple sites. The present invention makes use of a computer network (e.g., LAN, WAN or the World Wide Web) to convey recommended process sequences to the sites that are manufacturing a product or repairing a part. This assures uniform distribution of a recommended process sequence for the particular task. In one embodiment, the recommended process sequence is provided by a decision tree that is designed by manufacturing or repair experts and includes: (1) one or more questions that each require an answer; and (2) steps. In operation, the answers to the questions are used to determine which steps become part of a recommended process sequence. For example, if the feature of interest is a hole, there may be two different recommended sequences of steps to take in forming the hole depending on the diameter of the hole. This would be recognized in the decision tree by a question asking for the diameter of the hole that is to be produced and depending on the answer, providing one of two possible steps or sequence of steps for inclusion in the recommended process sequence. Both the questions and the steps embodied in a decision tree reflect the efficiencies that are of concern to the experts designing the decision tree. For example, the experts may be concerned about output per unit time, perishable tooling, quality of the resulting feature and the like. Moreover, the efficiencies that the experts are concerned about may be weighted. For instance, output per unit of time may be weighted more heavily than perishable tooling. If so, the decision tree will reflect a preference for increasing output over concerns about reducing the use of perishable tooling. Even in the absence of any weighting, it is not uncommon for the various efficiency

goals to conflict with another, thereby requiring the experts to make judgments concerning the design of the decision tree. Due to the conflicting goals, the design of the decision tree is typically determined by heuristic methods. Moreover, the design of the decision tree is subject to change if the efficiencies of concern or the weight accorded a particular efficiency concern changes.

The method of the present invention involves conveying a request from a manufacturing or repair site for a recommended process sequence for a particular feature or repair over a computer network. Once the request is received by a computer that has access to the decision tree, the request is processed to identify the recommended process sequence for producing the feature or repairing the part. Subsequently, the recommended process sequence is transmitted over the computer network for receipt at the requesting site. By extending the network to several sites, uniform distribution of recommended process sequences for manufacturing features or repairing parts is obtained and efficiencies realized.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic diagram of a distributed processing system that embodies the present invention;

Fig. 2 graphically illustrates one embodiment of a user interface or input screen for soliciting information from a user to form a request for a recommended process sequence;

Fig. 3 is a spreadsheet implementation of an input form for generating an input screen;

Fig. 4 is an architectural diagram of an embodiment of a computer system that receives requests for a recommended process sequence from a user's site and provides a recommended process sequence in response thereto;

Fig. 5 is a spreadsheet implementation of a decision tree used in providing a recommended process sequence; and

Fig. 6 is a spreadsheet implementation of "expert notes" used to supplement a recommended process sequence.

DETAILED DESCRIPTION OF THE INVENTION

Fig. 1 illustrates a distributed processing system 10 that is capable of uniform distribution of recommended process sequences to a number of manufacturing sites, where two or more sites are either manufacturing the same product, piece of a product, or a feature common to two or more products, or to a number of repair sites where common repairs are made. The system 10 includes: (1) one or more user computers 12A-12N that are each capable of transmitting requests for recommended process sequences over a digital communication network and receiving the recommended process sequences subsequently conveyed over the network in reply to the request; (2) a digital communication network 14 for conveying the requests and the recommended process sequences; and (3) a planner 16 that, in response to a request, provides a recommended process sequence for conveyance over the network 14 to the requesting user computer.

The network 14 can include any kind of digital communication network or combination of digital communication networks. For example, the network can

7

include a local area network (LAN), wide area network (WAN), World Wide Web or any combination of these networks. Likewise, the user computers 12A-12N and planner 16 can be of any form so long as the requests and

5   recommended process sequences can be communicated between the user computers 12A-12N and the planner 16. In the illustrated embodiment, the network 14 includes the World Wide Web. Consequently, the user computers 12A-12N each utilize a web browser to send a request and receive a

10   recommended process sequence. The planner 16 is also implemented in the form of a web server.

      The planner 16 provides each of the user computers 12A-12N with an interface that permits the user to convey requests for a recommended process sequence and receive

15   the recommended process sequence. The interface includes an input portion and an output portion. The input portion of the interface is used to convey information from the user's computer to the planner 16. The output portion conveys information from the planner 16 to the user

20   computer and is typically displayed on the monitor of the user's computer. However, the output portion is capable of being displayed on other output peripherals, like printers. Typically, the input information is generated by the user's actuation of an input peripheral, such as a

25   mouse or a keyboard. In the illustrated embodiment, the interface is provided by web pages that are transmitted by the planner 16 to each of the user computers 12A-12N. A web page includes input and/or output portions. The input portion of a web page allows the user to enter

30   information relevant to a request for a recommended process sequence with an input peripheral, such as a mouse or keyboard. The output portion of a web page is used to provide the user with the recommended process

sequence. In addition the output portion of a web page is used to solicit information relevant to a request for a recommended process sequence from a user. In this case, the web page includes both input and output portions.

In assembling a request for a recommended feature process sequence, the interface is initially used to solicit input from the user concerning the identification of the feature for which a recommended process sequence is desired. In the case of a request for a recommended repair process sequence, the interface is initially used to solicit input from the user concerning the repair for which a recommended repair process sequence is desired. In the illustrated embodiment, a web page is conveyed from the planner 16 to the user's computer that includes a hierarchical menu that allows the user to identify the type of process for which the user wants to request a recommended process sequence. Preferably, the highest level of the menu has the general types of manufacturing and repair processes for which recommended process sequences are to be generated. These could include, but are not limited to, manufacturing and repair processes such as hole making, welding, brazing, cleaning, part marking, composite laminating, adhesive bonding, grinding, thermal spray coating, diffusion coating, plating, etching, assembly, broaching, forging, forming, thread forming, tube bending, balancing, polishing, inspection (e.g., general, X-ray, eddy current, ultrasonic and penetrant inspection), laser drilling and cutting, electrical discharge machining, electro chemical machining, electro stream drilling, packaging, molding, gear shaping or forming, peening, blasting, riveting, soldering, casting, milling, turning and heat treat.

Various other processes could be included as well. Indeed, the present invention is not necessarily limited to manufacturing and repair processes, but could be applicable to any sort of process that is performed at multiple sites.

Under each top level menu item is a sub-menu that is used to identify the different types of features or repairs applicable to that top level menu item. For instance, under the hole making function, sub-menus for different features such as through-round hole and blind-round hole would reside. Likewise, under the welding function, there is a sub-menu that specifies different types of welding features, like a fillet and butt-joint, and so on for the other functions. Alternatively, it is possible that a sub-menu of different sub-processes could reside under one or more of the top level menu items. For example, under the welding function, there could be a sub-menu that specifies specific types of welding processes such as TIG, EB and resistance welding.

In most cases, the identification of a feature or repair does not provide sufficient data for a recommended process sequence to be specified. Consequently, the interface is used to solicit information from the user concerning the selected feature or repair. For instance, with respect to a hole feature, the user may specify the material in which the hole is to be drilled, the diameter of the hole, the depth of the hole and whether or not the hole is to be counter bored.

In the illustrated embodiment, the planner 16 provides a user's computer with an input form that causes a dynamically written input screen to be displayed on the user's monitor or other output peripheral. The input

screen allows the user to both select inputs from a menu of items already contained in the input form and to input information. Fig. 2 is an example of an input screen 18 for use in obtaining a recommended feature process

5   sequence for the manufacture of a hole. The input screen 18 includes a number of input windows 19 that allow the user to input the relevant information about the hole. As shown in Fig.2, input windows are included to solicit hole parameters such as the P11TF12 class (which

10   describes the significance of the hole to the life of the part in which it is being formed), the material in which the hole is to be made, the edge break type, the hole diameter and length, the number of holes to be made per part, the diameter tolerance, the minimum radius, whether

15   the hole is to be made with a normal entry, the true position tolerance, whether the hole is to be made with a normal exit, whether the hole has a counterbore, and, if so, the counterbore diameter and depth. Some of the input windows, such as those for the class, material and

20   edge break type, have pull-down menus that provide a list of possible inputs for the user to select. Other input windows, such as the normal entry, normal exit and counterbore windows, have pull-down menus from which the user can select a yes or no answer. The remaining input

25   windows simply allow the user to input an appropriate numerical value. Thus, by way of example, the user is permitted to: (1) select one of a number of materials in which the hole is to be drilled; (2) input a yes/no answer to a counterbore query; and (3) input a value for

30   the length of the hole. The input screen would be configured for different parameters when dealing with processes other than hole making.

The input form that causes the input screen to be generated is preferably in a spreadsheet format, as shown in Fig. 3. The input form includes an input parameter column 20 that identifies each parameter, corresponding to a respective one of the input windows 19, for which input is being solicited from the user. Two positioning columns 21 are provided for controlling the relative positions of the input windows 19 on the input screen 18. Also included in the spreadsheet are one or more input value columns 22 that dictate whether the corresponding input window will: (a) provide the user with a number of selections for a parameter; (b) solicit a yes/no entry from the user for a parameter; or (c) solicit a numerical value for a parameter from the user. For instance, the input value columns 22 corresponding to the material parameter are filled with the types of materials the user could select from the pull-down menu associated with that input window. Similarly, the input value columns 22 corresponding to the normal entry parameter have yes and no entries, allowing the user to select a yes or no input. The input windows corresponding to parameters for which the input value columns 22 are vacant will not have a pull-down menu; the user enters a numerical value in these input windows. While other types of formats are possible for obtaining the information needed for the request, the spreadsheet format is a format that is readily understood by the users, even if they have had no prior experience with this format.

The planner 16 is capable of receiving a request for a recommended process sequence and responding to the request with a recommended process sequence. In the illustrated embodiment as shown in Fig. 4, the planner includes a web page / graphical user interface ("GUI") 26

12

for receiving a request from the network 14 for a recommended process sequence and transmitting a recommended process sequence to the network 14 that is directed to the requesting user's computer. Also part of the planner 16 is a decision maker engine 28 that, in response to a request conveyed by the GUI or other network interface, assembles a recommended process sequence. The decision maker engine 28 uses a decision tree library 30 to provide a recommended process sequence. Additionally, a notes decision tree library 32 is used by the decision maker engine 28 to obtain error proofing and best practice information.

The decision tree library 30 is comprised of a decision tree for each feature or repair. For instance, and by way of example, there may be a decision tree for hole making, welding, brazing, cleaning, part marking, composite laminating, adhesive bonding, grinding, thermal spray coating, diffusion coating, plating, etching, assembly, broaching, forging, forming, thread forming, tube bending, balancing, polishing, inspection (e.g., general, X-ray, eddy current, ultrasonic and penetrant inspection), laser drilling and cutting, electrical discharge machining, electro chemical machining, electro stream drilling, packaging, molding, gear shaping or forming, peening, blasting, riveting, soldering, casting, milling, turning and heat treat. A decision tree sets forth the decisions that must be made to determine which of a number of possible steps that may be applicable to a process become part of a recommended process sequence. The construction of a decision tree is done by one or more experts that define the decisions that must be made, the sequence of decisions, and the steps associated with each decision. Typically, this construction process is

13

based upon several efficiency related considerations. For example, the experts may be concerned about the output per unit time, perishable tooling, quality of the resulting feature and the like. Moreover, the efficiencies that the experts are concerned about may be weighted. For instance, output per unit of time may be weighted more heavily than perishable tooling. If so, the resulting decision tree will embody a preference for increasing output over concerns about reducing the use of perishable tooling. Even if one type of efficiency is not weighted over another, the various efficiency considerations may compete against one another, thereby requiring the experts to make choices in the design of a decision tree that do not necessarily serve one or more of the identified efficiency considerations. Based on the foregoing, the design of a decision tree is typically determined by heuristic methods and is subject to change based upon changes in the efficiencies that are of concerned and/or the weights accorded the efficiencies of concern.

A decision tree can be comprised entirely of steps. However, the typical decision tree includes at least one decision node that, based upon a decision, is used to determine whether or not a step or sequence of steps are to become part of the recommended process sequence that is transmitted in response to a user's request. The decision for each decision node is embodied in the request. For instance, a request for a recommended process sequence for a hole might include a decision as to whether the hole is to be counter bored. When the decision maker engine 28 traverses the decision tree, a decision node is encountered that requests a decision as to whether or not the hole is to be counter bored. If

14

the request indicates that the hole is to be counter bored, the decision maker engine 28 includes steps relating to counter boring in the recommended process sequence. If the hole is not to be counter bored, the decision maker engine 28 skips the steps relating to counter boring in the decision tree and continues traversing the decision tree at a point after the counter boring steps.

The decision trees in the library 30 are implemented in spreadsheet format to facilitate the construction and alteration of the decision tree by the experts. Fig. 5 is an example of a decision tree spreadsheet for creating a hole. The spreadsheet includes: (1) a node index column 36; (2) a type column 38 that for each node, identifies the node as either a step node or a decision node; (3) a description column 40 that provides either: (a) a description of the step associated with a step node, which in some cases includes data that is necessary for calculation; or (b) a simple question mark identifier for each decision node; (4) a characteristic column 42 that for each decision node, identifies the parameter for which there should be a value in the input form; (5) a value column 44 that for each decision node, includes a decision value; (6) an operator column 46 that for each decision node, contains an operator that defines the manner in which the value of the parameter identified in the characteristic column is to be compared to the decision value in the value column; and (7) a next node column 48 that for each decision node, identifies the next node in the tree that is to be traversed if the comparison of the input value to the decision value is true or if the comparison is false.

The decision maker engine 28 traverses a decision tree beginning at node 0 and proceeding through the tree until the final node of the tree is encountered. In Fig. 5, the final node is identified as node 999. At each node of the tree either a decision node is encountered or a step node. The decision nodes are used to determine which of the steps set forth in the decision tree are used to construct the recommended process sequence. If a decision node is encountered, the value for the parameter identified in the characteristic column and obtained from the input form is compared to the decision value according to the defined operator. If the comparison is true, the decision maker engine continues traversing the tree at the first node identified in the next node column 48. If the comparison is false, the decision maker engine continues traversing the tree at the second node identified in the next node column 48. Whenever the decision maker engine 28 encounters a step node, the step set forth in the description column of the step node is added to the recommended process sequence. As an example of the whether or not a step is added to the recommended process sequence, the step in the description column of node 2 in Fig. 5 is added to the recommended process sequence if the value of the shaped hole minor diameter parameter is less than 0.52 inches. If the value of the shaped minor hole minor diameter parameter is equal to or greater than 0.52 inches, the step in the description column of node 2 is not added to the recommended process sequence.

The decision maker engine 28 also accesses the notes decision tree library 32 that is comprised of a notes decision tree for each basic decision tree. A notes decision tree sets forth the known error proofing

16

techniques and best practices to follow in creating the feature or making a repair. Like a basic decision tree, a notes decision tree is assembled by experts that define the error proofing and best practices to follow in creating the feature or making the repair. The notes decision tree may also reflect the efficiencies that are of concern.

A notes decision tree includes a plurality of "note" nodes that each correspond to a step node in the basic decision tree and provide a note that relates to the step set forth in the step node. In operation, if a step from the basic decision tree is added to the recommended process sequence, the corresponding note from the note decision tree is considered for inclusion in the recommended process sequence. Whether or not a note is included in the recommended process sequence may depend on the answer to a query. The answer to the query is present in either the recommended process sequence or the input form.

The notes decision trees in the library are implemented in spreadsheet format. Fig. 6 is an example of a notes decision tree for use in drilling a hole. The spreadsheet includes: (1) a node index column 50; (2) a type column 52 that identifies each of the nodes in the tree as a "note" node; (3) a description column 54 that sets forth the error proofing and/or best practice to use in executing a particular step in the recommended process sequence being built from the decision tree; (4) a characteristic column 56 that for each note node, identifies the parameter for which there should be a value in the recommended process sequence or input form; (5) a value column 58 that for each note node, includes a

17

decision value; (6) an operator column 60 that for each note node, contains an operator that defines the manner in which the value of the parameter identified in the characteristic column is to be compared to the decision value in the value column; and (7) a next node column 62 that for each note node identifies the next node in the tree that is to be traversed if the comparison of the input value to the decision value is true and if the comparison is false. As an example of the whether or not a note is added to the recommended process sequence, the note in the description column of node 5 in Fig. 6 is added to the recommended process sequence if the process, which is either the recommended process sequence or the input form, contains the word chamfer. As an alternative to separate notes decision trees, the contents of the notes decision trees could be incorporated into the corresponding basic decision trees.

Also part of the planner 16 is a resolver 66 that receives the recommended process sequence output by the decision maker engine 28, identifies situations in which information is needed to complete the recommended process sequence, acts to obtain the information, and outputs the completed sequence to the GUI 26. The resolver 66 identifies the need for further information by looking for keywords in the steps and notes contained in the recommended process sequence that indicate further information is needed. Any information that is needed to complete the sequence relates to process specific information that cannot be readily resolved with a decision tree. If the resolver 66 identifies the need for further information to complete the recommended process sequence, a process calculator 68 is used to obtain the needed information. The process calculator 68

18

has access, if needed, to one or more databases 70A-70N that provide information that is used in conjunction with information contained in a step to provide the necessary information. For instance, if the recommended process sequence relates to the drilling of a hole, the resolver 66 may call on the process calculator 68 to provide information with respect to which drill to use, the speed at which the drilling should be done and the coolant to be used during the drilling process. Once all of the information needed to complete the recommended process sequence has been obtained from the calculator 68, the recommended process sequence is provided to the GUI 26. In response, the GUI 26 provides the recommended process sequence to the network 14 for conveying to the requesting user's computer. The recommended process sequence is also in the form of a spreadsheet that lists the recommended steps for producing the feature or repair specified by the user and if appropriate, the error proofing and/or best practices associated with each step.

It is also feasible to integrate the planner 16 into each of the user computers 12A-12N to create a stand-alone system. In this case, it is feasible to use the network 14 to update the planner 16 resident in each of the computers 12A-12N. The stand-alone system is particularly useful in situations where the integrity or ability to use the network 14 is unreliable. It is also feasible to download the planner 16 to the user computer each time a recommended process sequence is requested from the planner 16.

The foregoing description of the invention has been presented for purposes of illustration and description. Further, the description is not intended to limit the

19

invention to the form disclosed herein. Consequently, variations and modifications commensurate with the above teachings, and the skill or knowledge in the relevant art are within the scope of the present invention. The preferred embodiment described hereinabove is further intended to explain the best mode known of practicing the invention and to enable others skilled in the art to utilize the invention in various embodiments and with the various modifications required by their particular applications or uses of the invention. It is intended that the appended claims be construed to include alternate embodiments to the extent permitted by the prior art.

CLAIMS:

1.   A   method   for   distributing   information
concerning recommended steps for performing a process,
comprising:

providing   a   computer   network   for   communicating
5   digital data between at least two locations;

first   conveying,   using   said   computer   network,   a
request for a recommended process sequence of steps for
performing a process, said request originating at a first
location and directed to a second location;

10   processing, at said second location, said request to
produce said recommended process sequence of steps for
performing said process; and

second conveying, in response to said request and
using said computer network, a response that includes
15   said recommended process sequence of steps for performing
said process, said response originating at said second
location and directed to said first location.

2.   The method as claimed in Claim 1, wherein:
said processing includes using a decision tree for
20   use in determining said recommended process sequence of
steps.

3.   The method as claimed in Claim 2, wherein:
said decision tree includes a decision node that,
based upon a decision, is used determine if a first
25   sequence of steps or a second sequence of steps is part
of said recommended process sequence of steps.

4.   The method as claimed in Claim 1, wherein:
said processing includes using a notes tree for
providing error proofing directions for said recommended
30   process sequence of steps in said response.

21

5.   The method as claimed in Claim 1, wherein:

said processing includes using a notes tree for providing best practices directions for said recommended process sequence of steps in said response.

6.   The method as claimed in Claim 1, wherein:

said processing includes using a tree structure that is in the form a spreadsheet.

7.   The method as claimed in Claim 1, wherein:

said processing includes calculating a value associated with a step of said recommended process sequence of steps.

8.   The method as claimed in Claim 7, wherein:

said calculating includes using a data file.

9.   The method as claimed in Claim 7, wherein:

said calculating includes using a data file that is in the form of a spreadsheet.

10. A method for distributing information concerning recommended steps for performing a process, comprising:

providing a computer network for communicating digital data between at least two locations;

first conveying, using said computer network, a request for a recommended process sequence of steps for performing a process, said request having originated at a first location and being directed to a second location; and

second conveying, in response to said request and using said computer network, a response that includes said recommended process sequence of steps for performing said process, said response having originated at said

second location and being directed to said first
location.

11.   The method as claimed in Claim 10, wherein:
said network includes the World Wide Web.

12.   The method as claimed in Claim 10, wherein:
said providing includes providing one of the
following: a local area network and a wide area network.

13.   The method as claimed in Claim 10, wherein:
said first conveying includes conveying said request
in the form of a spreadsheet.

14.   The method as claimed in Claim 10, wherein:
said second conveying includes conveying said
response in the form of a spreadsheet.

15.   The method as claimed in Claim 10, wherein:
said second conveying includes conveying said
recommended process sequence of steps in the form of a
spreadsheet.

16.   A method for providing information concerning
recommended steps for performing a process, comprising
the steps of:
providing, in a computer memory, a decision tree
having at least two possible sequences of steps for
performing a process;
receiving a request, originating from a computer
input device, for a recommended process sequence of steps
for performing said process, said request including
information for use in determining a recommended process
sequence of steps from said at least two possible
sequences in said decision tree;

using, in a digital computer, said request and said decision tree to determine a recommended process sequence of steps for performing said process of a product; and

transmitting said recommended process sequence of steps towards a computer output device.

17. The method as claimed in Claim 16, further comprising:

permitting an expert to modify said decision tree.

18. The method as claimed in Claim 16, further comprising:

receiving said decision tree from a remote location relative to said digital computer.

19. The method as claimed in Claim 16, wherein:

said step of receiving includes conveying said request over a computer network.

20. The method as claimed in Claim 16, wherein:

said step of transmitting includes conveying said recommended process sequence of steps over a computer network.

PROCESS PLANNING FOR DISTRIBUTED
MANUFACTURING AND REPAIR

ABSTRACT OF THE DISCLOSURE

The present invention relates to a method for optimizing the performance of a process, especially where the process is performed at several different locations. In one embodiment, one or more experts produce a

5 decision tree for use in determining a recommended sequence of steps for the process. A computer network, such as the World Wide Web, is used to convey a request to a computer that has access to the decision tree for a recommended sequence of steps. The request includes any

10 information that is needed by the decision tree to determine the recommended sequence of steps. In response to the request, the computer uses the information in the request and the decision tree to produce the recommended sequence of steps. The recommended sequence of steps is

15 then directed over the network to the user.

Fig. 1

PLANNER *16*

WORLD WIDE WEB *14*

USER COMPUTER #1 *12A*

USER COMPUTER #2 *12N*

10
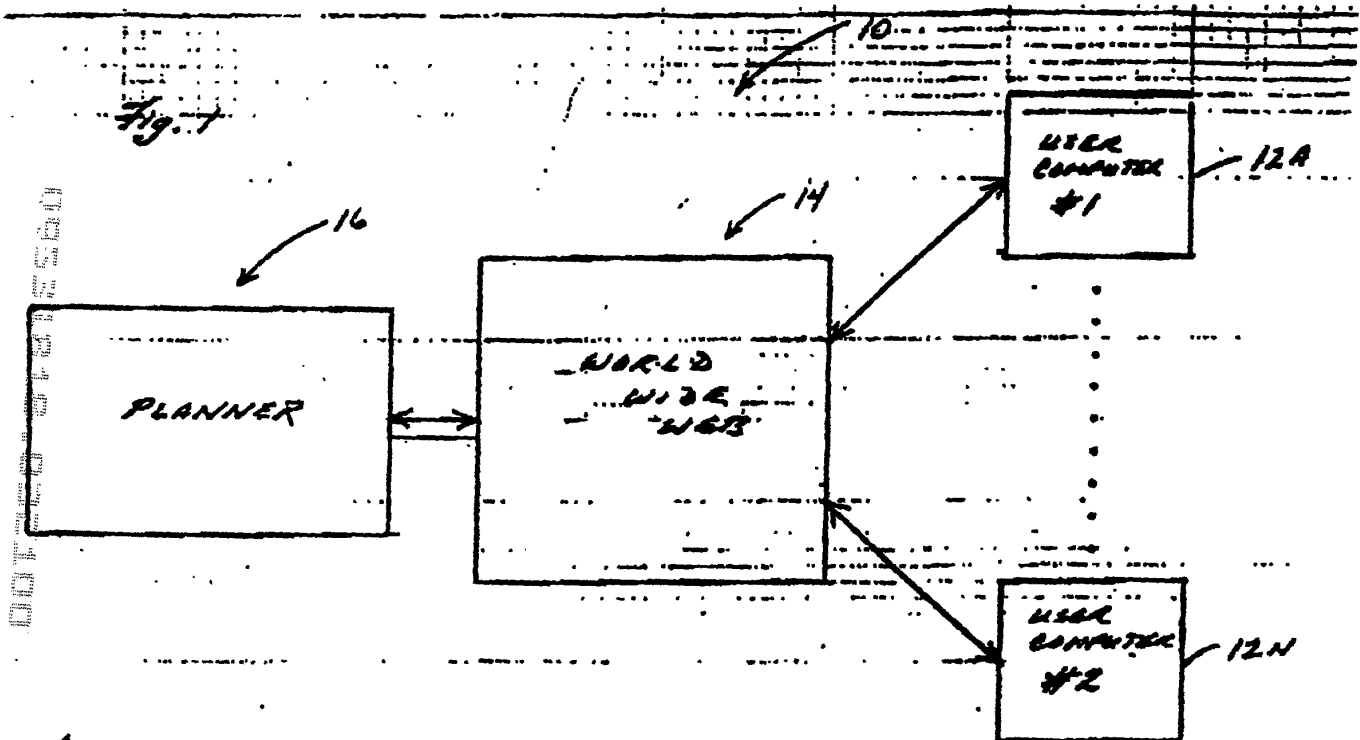
PIITF12 Class ▽ _19_

Material ▽ _19_

Edge Break Type ▽ _19_

Hole Dia. _19_

Hole Length _19_

Number of Holes _19_

Diameter Tol. _19_

Min Rad _19_

Normal Entry ▽ _19_

True Position Tol _19_

Normal Exit ▽ _19_

Counterbore? ▽ _19_

Counterbore Dia _19_

Counterbore Depth _19_

_18_

FIG. 2

20 21 22

14				A	B	C	D	E	F	G
P11TF12 Class	1	1	None	A	B	C	D	E	F	G
Material	1	2	Inco	R41	Waspalloy	R95	R88	Titanium	A286	MA-250	MAR-509
Edge Break Type	1	3	Chamfer	Radius						
Shaped Hole Minor Dia	3	1								
Hole Length	3	2								
Number of Holes	3	3								
Diameter Tol	5	1								
Min Rad	5	2								
Normal Entry	5	3	Yes	No						
True Position Tol	7	1								
Normal Exit	7	3	Yes	No						
Counterbore?	9	1	No	Yes						
Counterbore Dia	9	2								
Counterbore Depth	9	3								

Fig. 3

Fig. 4
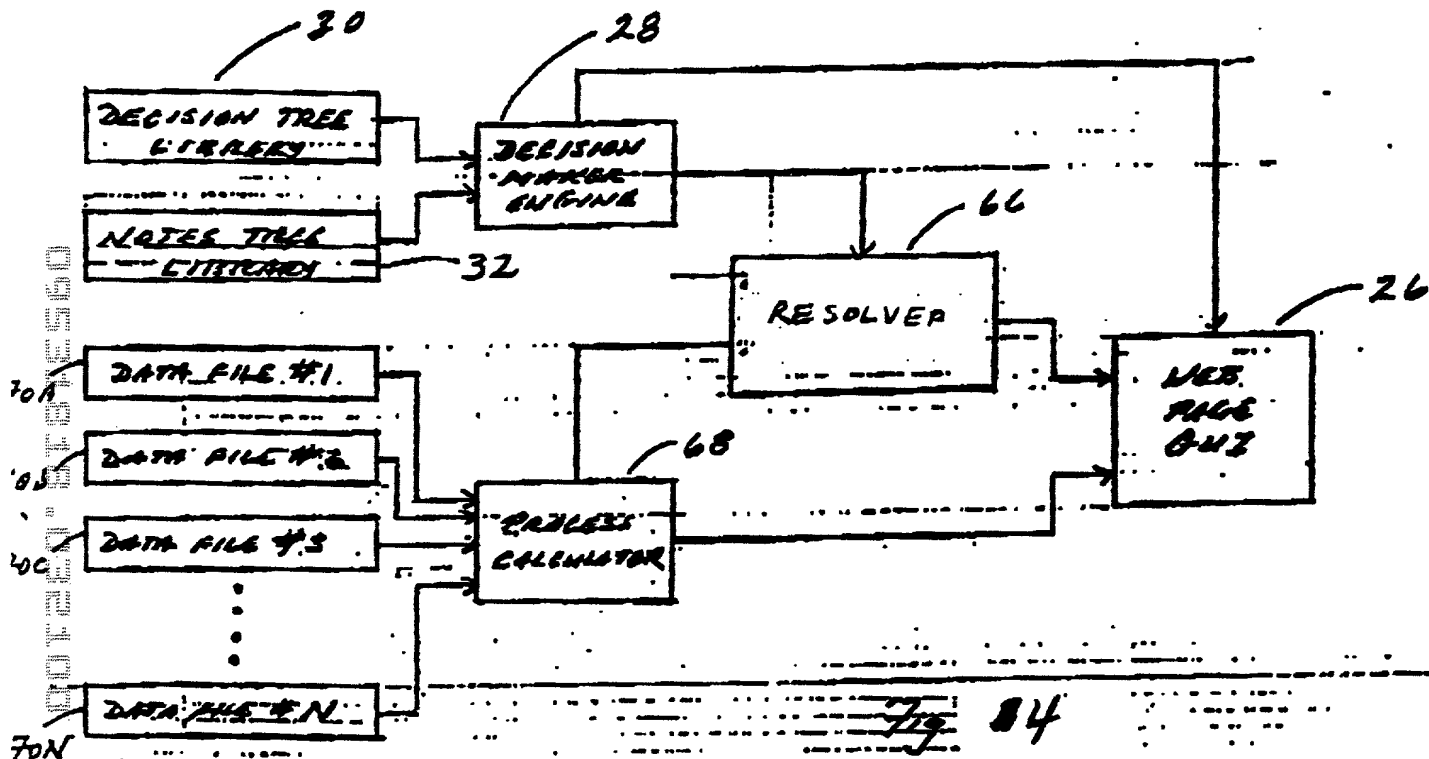
NodeIndex /36	Type /38	Description /40	Characteristic /42	Operator /46	Value /44	NextNode /48
0	Decision	?	Normal Entry	=	No	1
						4
			Shaped Hole Minor Dia	<	6.62	2
1	Decision	?				3
						5
2	Step	Rough Endmill				4
3	Step	Endmill flat; size=.437				5
4	Step	Rough Drill; u/size=.012				6
5	Step	Finish Peripheral mill; u/size=.005	P11TF12 Class	=	D	7
6	Decision	?				8
						6
7	Step	Abrasive Flow Post-Fin; size=.001 min	Counterbore?	=	Yes	9
8	Decision	?				10
						10
9	Step	Counterbore				11
10	Step	Chamfermill top and bottom				999
11	Step	Bench edgebreak; size=320 grit b'fly				

Fig. 45

NodeIndex (50)	Type (52)	Description (54)	Characteristic (56)	Operator (60)	Value (58)	NextNode (62)
0	Note	Use flood coolant at all times		contains	Thru	988
4	Note	Use approximately .050 overtravel on drill stroke	database	contains	Chamfer	987
5	Note	Climb Mill while milling	process	contains	Peripheral	984
6	Note	Climb Mill while milling	process	contains	Chamfer	982
7	Note	Use one section of cutter flutes for roughing; another for finishing	process	contains	Peripheral	989
8	Note	Use one section of cutter flutes for roughing; another for finishing	process	contains	Flexhone	986
9	Note	Reverse flexhone spindle direction 1/2 way thru hole pattern	process	contains	Coolant Fed Drill	985
10	Note	Alternate peck drill cycle: 1/2 Dia deep; retract fully; than 1/10 Dia deep; retract fully; repeat as req'd	process	contains	Coolant Fed Drill	984
11	Note	Coolant pressure of 200+ psi recommended for CF Drilling	process	<	0.002	986
14	Note	Align workpiece & spindle only after running warmup routine for this application	True Position Tol	contains	Shaped	985
18	Note	When shaped hole milling; rough w/ used cutter; finish with new cutter	database	<	0.002	986
19	Note	Consider Hydraulic Toolholders for this application	True Position Tol	<	0.001	986
20	Note	Align cutter flutes w/in .0002 inches before finish pass	True Position Tol			

Fig. 6

DECLARATION AND POWER OF ATTORNEY
FOR PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address, and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

PROCESS PLANNING FOR DISTRIBUTED MANUFACTURING AND REPAIR

_____

_____

_____ ,

the specification of which

☒ is attached hereto
OR

☐ was filed on _____ as United States Application Number or PCT International Application Number _____
and was amended on _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37 Code of Federal Regulations, §1.56.

I hereby claim foreign priority benefits under Title 35, United States Code §119 (a)-(d) or §365 (b) of any foreign application(s) for patent or inventor's certificate, or §365 (a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below any foreign application for patent or inventor's certificate, or of any PCT international application having a filing date before that of the application on which priority is claimed.

PRIOR FOREIGN APPLICATION(s)   **Priority Claimed**

_____   _____   _____   ☐ Yes ☐ No
(Number)   (Country)   (Day/Month/Year Filed)

_____   _____   _____   ☐ Yes ☐ No
(Number)   (Country)   (Day/Month/Year Filed)

☐ Additional foreign application numbers are listed on a supplemental priority data sheet attached hereto.

I hereby claim the benefit under Title 35, United States Code §119 (e) of any United States provisional application(s) listed below.

_____   _____   ☐ Additional provisional application
(Application Number)   (Filing Date)   numbers are listed on a
                                                                                                   supplemental priority data sheet
                                                                                                   attached hereto.

I hereby claim the benefit under Title 35, United States Code §120 of any United States Application(s), or §365 (c) of any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code §112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations §1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

_____   _____   _____
(Application Number)   (Filing Date)   (Status - patented, pending, abandoned)

_____   _____   _____
(Application Number)   (Filing Date)   (Status - patented, pending, abandoned)

I hereby appoint the registered practitioners associated with Customer Number 006111 to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith.

Address all telephone calls to: ___WILLIAM SCOTT ANDES___ at telephone number ___(513) 243-5955___

Address all correspondence to: **GENERAL ELECTRIC COMPANY**
ATTN: ANDREW C. HESS
GE AIRCRAFT ENGINES
ONE NEUMANN WAY, M/D H17
CINCINNATI, OH 45215-6301

GEAE (9/97)

CUSTOMER NUMBER: 006111

Place Customer
Number Bar Code
Label here
PATENT TRADEMARK OFFICE

006111

Page 1 of 2

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

SOLE OR FIRST INVENTOR:

Full name: CHRISTOPHER R. HAMMOND
       First Name   Middle Name   Last Name

Signature: _____   Date _____

Residence: SCHENECTADY, NEW YORK   Citizenship: US
       City and State

Post Office Address: 404 DEER PATH, SCHENECTADY, NY 12306

SECOND JOINT INVENTOR:

Full name: JEFFREY S. KELLER
       First Name   Middle Name   Last Name

Signature: _____   Date _____

Residence: CINCINNATI, OHIO   Citizenship: US
       City and State

Post Office Address: 10505 HOPEWOODS COURT, CINCINNATI, OH 45249

THIRD JOINT INVENTOR:

Full name: DAVID A. BEACH
       First Name   Middle Name   Last Name

Signature: _____   Date _____

Residence: CLIFTON PARK, NEW YORK   Citizenship: US
       City and State

Post Office Address: 38D HOLLANDALE APTS., CLIFTON PARK, NY 12065

FOURTH JOINT INVENTOR:

Full name: _____
       First Name   Middle Name   Last Name

Signature: _____   Date _____

Residence: _____   Citizenship: _____
       City and State

Post Office Address: _____